Study ZnSb Phase Change Material Alloys for Nonvolatile Embedded-Memory Applications

H. Neggaz, J. Remondina, M. Bertoglio, M. Putero, A. Portavoce

[a] *IM2NP,Université Aix Marseille , CNRS-UMR 7334, 13013 Marseille, France*

Phase-change materials (PCMs) play a key role in emerging memory technologies, particularly in resistive phase-change memories (PCRAM). Among well-studied PCMs, GeSbTe (GST) [1], GaSb [2], and SbTe [3] stand out. Our study focuses on ZnSb alloy, a promising intermetallic semiconductor, exhibiting a crystallization temperature of 257°C, an activation energy of 5.63 eV, thermal stability of 10 years at 201 °C, and a resistivity contrast of approximately 10^{-4} Ω/sq between its amorphous and crystalline states [4]. The objective is to explore the atomic redistribution mechanisms, physico-chemical phenomena and crystallization process during the thermal annealing of ZnSb alloys and Zn-Sb bilayers. To this end, various samples were deposited using magnetron sputtering: deposition from an alloyed ZnSb (50:50) target, co-deposition of Zn and Sb targets with composition variations, and bilayer deposition to study reactive diffusion. *In situ* X-ray diffraction (XRD) was used to monitor phase sequences and determine crystallization temperatures as shown in Fig 1, while X-ray reflectivity (XRR) provided insights into thickness and density changes in the layers before and after thermal treatment. Additionally, atom probe tomography provided detailed insights into atomic compositions, further enriching the understanding of phase formation processes. A notable result was the consistency of the phase sequence (formation of Zn_4Sb_3 followed by ZnSb) regardless of the deposition method, although the ZnSb phase formation temperature varied depending on the method employed.

Index terms: phase change memory (PCM), ZnSb compound, phase sequence, reactive diffusion, crystallization temperatures, density changes.

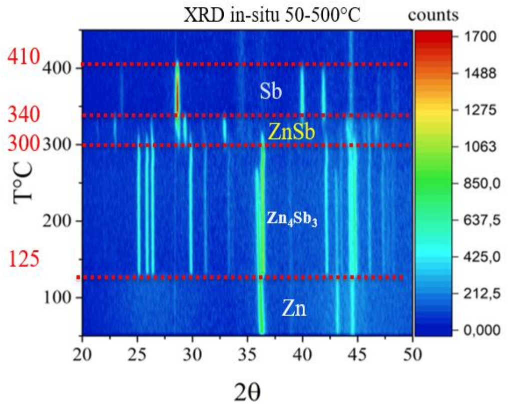

Fig 1 : *in situ* XRD recorded during ramp annealing (5°C/min) on a Zn/Sb Bi-layer. The horizontal dotte dred lines deliminate the temperature domain of each phases.

References

1. GOMIERO, E., SAMANNI, G., JASSE, J., et al. Crystallization speed in Ge-rich PCM cells as a function of process and programming conditions. IEEE Journal of the Electron Devices Society, 2019, vol. 7, p. 517-521.
2. UME, Rubab, GONG, Haibo, TOKRANOV, Vadim, et al. Electrical and structural properties of binary Ga–Sb phase change memory alloys. Journal of Applied Physics, 2022, vol. 132, no 3.
3. ZHU, Min, WU, Liangcai, RAO, Feng, et al. Uniform Ti-doped Sb2Te3 materials for high-speed phase change memory applications. Applied Physics Letters, 2014, vol. 104, no 5
4. CHEN, Yimin, WANG, Guoxiang, SHEN, Xiang, et al. Crystallization behaviors of Zn x Sb 100− x thin films for ultralong data retention phase change memory applications. CrystEngComm, 2014, vol. 16, no 5, p. 757-762.

* *Hamid NEGGAZ e-mail:* hamid.neggaz@im2np.fr